Comparison of Chemical Compositions Between Two Fast Growing Species: *Acacia mangium* and *Leucaena leucochephala*

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Comparison of Chemical Compositions Between Two Fast Growing Species: *Acacia mangium* and *Leucaena leucochephala*

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Abstract. *Acacia mangium* and *Leuceana leucocephala* are both exotic species known to be planted in Malaysia. Both species are well known to possess high growth rate, therefore made as reforestation species as well as a popular resource for pulp and paper industry. The main objectives of this study are to determine the chemical compositions of small diameter wild *Acacia mangium* and *Leucaena leucocephala* species and to compare that properties between of them at three (3) different stem portions (bottom, middle and top) and two (2) different parts (bark and wood). All analyses were done according to TAPPI standard method, except hemicellulose (Wise *et al.*) and holocellulose (formula). All the data and results were statistically analyzed using ANOVA and Tukey's Post Hoc test. Results revealed alcohol-toluene solubles was highest in bottom portion of *Acacia mangium* bark (14.98%). Holocellulose can be found highest in middle portion of *Leuceana leucocephala* wood (90.61%). For α-cellulose, highest was in *Leuceana leucocephala* bark (69.36%). Hemicellulose was most abundant in *Acacia mangium* top portion of wood (36.14%), while highest lignin was in its bottom portion of bark (31.18%). ANOVA indicates there are statistically high significance between species for all chemical composition, but between portions, only alcohol-toluene soluble and holocellulose are significant. For parts, all chemical composition is significant, except for lignin. This study proved that small diameter wild *Acacia mangium* and *Leuceana leucocephala* as a viable resource for pulp and paper industry.

1. Introduction

Acacia mangium and *Leucaena leucocephala* ae both exotic species found in Malaysia. Both species was introduced into this country as reforestation species and due to resistant nature, both species became invasive species [1]. *Acacia mangium* is a species of flowering tree in the pea family, Fabaceae. Although it was brought from Australia to be made as a reforestation species, it is now very common in Malaysia due to high resistance and survivability [2, 3]. *Leucaena leucocephala* is a vigorous shrub or small tree of dry lowlands throughout the Hawaiian Islands, also of larger size on moderately wet sites. This neutralized deciduous species is characterized by twice-pinnate leaves with numerous small gray green leaflets [4, 5].

Both species has been regarded as useful trees, as many product and uses can be made from *Acacia mangium* and *Leucaena leucocephala*. *Acacia mangium* has many uses like the glossy and smooth surface finish after polishing leads also possible to be made as export orientated parquet flooring tiles and artifacts [6, 7]. According to database provided by Orwa *et al.* [8], several known uses are made off *Acacia mangium*, domestically and commercially, including as animal fodder, fibre and tannin/dyestuffs. Usage of *Leucanena leucophala* includes reforestation, forage for domestic animals, poles for construction, firewood, shades in permanent plantations, pulp production, woods production and in traditional medicine [9, 10].

2. Materials and Methods

The materials used in this study of chemical compositions were wild species of small diameter *Acacia mangium* and *Leucaena leucocephala* which were cut into three (3) portions (bottom, middle and top) and were divided into two (2) parts which were wood and bark. The diameters that were collected are about 5-8 cm of its diameter breast height (DBH), randomly selected. *Acacia mangium* samples were collected in Jeli, Kelantan, while *Leucaena leucocephala* were collected from Lenggong, Perak. All samples reduced into chips using chipper. Samples then be dried at 103±2ºC for 24 hours to reduce the moisture content. The chips then reduced into coarse particle by using laboratory type mill. Finally, all the coarse particle reduced into fine particles of less than 1mm in diameter with laboratory grade mill.

Chemical analyses conducted to determine the content of alcohol-toluene extractives or solubles, α-cellulose, and lignin was according to TAPPI standard T 204 cm-97 [11], T 203 cm-99 [12] and T 222 om-02 [13]. For holocellulose, Wise *et al.* [14] method was used. Hemicellulose content determined using equation by Boonstra & Tjeerdsma [15].

3. Results and Discussion

Chemical compositions were varied between these two species. The mean values were calculated in order to easily identify the range of values for each of the dependent variables which are extractive, holocellulose, α-cellulose, hemicellulose and lignin for each of the portions and parts of both species. Table 1 shows the mean value of chemical compositions for *Acacia mangium* and *Leucaena leucocephala*, meanwhile Table 2 shows the ANOVA for those chemical compositions while Table 3 shows the summary of Tukey's Post Hoc Test on chemical compositions between portions of small diameter wild *Acacia mangium* and *Leucaena leucocephala*.

Table 1. Mean value of chemical compositions for small diameter wild *Acacia mangium* and *Leucaena leucocephala* according to portions and parts

Species	Part	Portion	Chemical Composition (%)				
			Alcohol-Toluene	Holocellulose	α-cellulose	Hemicellulose	Lignin
Acacia mangium	Wood	Bottom	1.4	82.23	47	35.22	21.07
		Middle	1.86	83.95	48.16	35.79	21.06
		Top	2.05	85.99	49.84	36.14	17.23
	Bark	Bottom	14.98	57.36	46.09	11.27	31.18
		Middle	9.93	61.78	47.24	15.53	28.8
		Top	5.14	68.89	48.25	20.63	22.68
Leucaena leucocephala	Wood	Bottom	0.8	88.35	61.18	28.6	25.22
		Middle	0.95	90.61	55.87	34.74	18.63
		Top	1.41	90.28	58.75	31.54	24.2
	Bark	Bottom	1.58	73.14	67.75	5.39	9.57
		Middle	2.63	70.79	69.36	1.43	19.12
		Top	4.11	71.01	66.65	4.36	15.9

Table 2. ANOVA on the chemical compositions of small diameter wild *Acacia mangium* and *Leucaena leucocephala*

Source	df	Alcohol-Toluene	Holocellulose	α-cellulose	Hemicellulose	Lignin
Species	1	160.605**	197.952**	68.848**	17.351**	25.433**
Portion	***2***	***9.707****	***17.710*****	***0.049ns***	***0.855ns***	***1.583ns***
Part	1	329.663**	1436.401**	4.800*	160.059**	0.001ns

Note: **significant at p<0.01; *significant at p<0.05; df-degree of freedom

Table 3. Summary of Tukey's Post Hoc Test on chemical composition between portions of small diameter wild *Acacia mangium* and *Leucaena leucocephala*

Source	Chemical Composition				
Portion	Alcohol-Toluene	Holocellulose	α-cellulose	Hemicellulose	Lignin
	9.707*	***17.710*****	***0.049ns***	***0.855ns***	***1.583ns***
Bottom	4.69a	75.27a	55.51a	20.12a	21.76a
Middle	4.29a	76.79a	55.16a	21.62a	21.91a
Top	3.18b	79.04b	55.87a	23.17a	20.01a

3.1 Alcohol-Toluene Soluble Content

Extractives present in plants may be extracted using alcohol-organic solvent. They are found in higher concentrations in the bark of most woods and are generally considered to be biosynthesized in order to slow or prevent pathogen invasion. According to Zhang *et al.* [16], *Acacia mangium* bark extract are known to have high phenolic contents.

Based on Figure 1, highest alcohol-toluene soluble was in *Acacia mangium* bottom bark (14.98%). *Acacia mangium* generally has higher content of alcohol-toluene soluble, compared to *Leucaena leucocephala*, which is very evident for bark part. For wood part of both species, there was not much difference. Table 2 shows that alcohol-toluene soluble content are statistically significant between species (r = 160.605**), portion (r = 9.707*) and part (r = 329.663**). Tukey's Post Hoc Test in Table 3 shows top portion are statistically significant compared to bottom and middle portion, while between bottom and middle, there is no statistical significance for alcohol-toluene soluble.

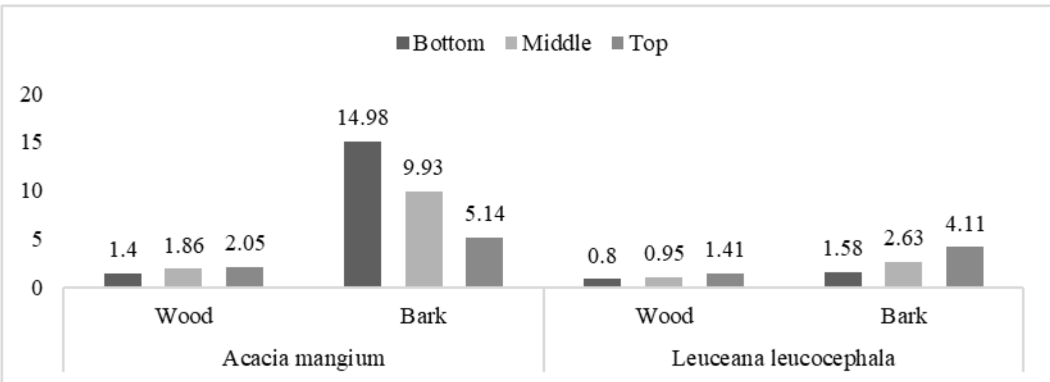

Figure 1. Comparison of alcohol-toluene soluble percentage between small diameter wild *Acacia mangium* and *Leucaena leucocephala* species in portions and parts

3.2 Holocellulose Content

Holocellulose is the amount of polysaccharide fraction of wood or straw, made up cellulose and hemicelluloses polymers. The values of comparisons for the holocellulose percentage between *Acacia mangium* and *Leucaena leucocephala* species between portions and parts shown in Figure 2.

Leucaena leucocephala generally has higher content of holocellulose, and its middle portion of wood has highest holocellulose content (90.61%). ANOVA in Table 2 shows that holocellulose content is statistically highly significant for species (r = 197.952**), portions (r = 17.710**), and parts (r = 1436.401**). Tukey's Post Hoc Test in Table 3 shows holocellulose content is statistically significant in bottom compared to middle and top. Lim *et al*. [17] further stated that wood with high cellulose content can be a promising resource for pulp and paper industries, as higher cellulose content means higher pulp yield.

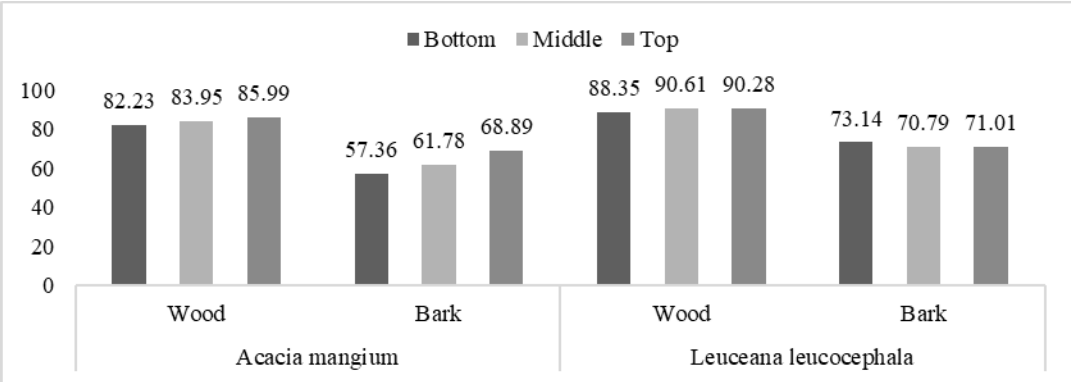

Figure 2. Comparison of holocellulose percentage between small diameter wild *Acacia mangium* and *Leucaena leucocephala* species in portions and parts

3.3 α-cellulose Content

The α-cellulose synthesized within cells from a glucose-based sugar nucleotide derived from combining a sugar with a phosphate group and a base constituting of RNA or DNA. α-cellulose is the major component of wood and paper pulp. It was separated from the other components by soaking the pulp in a 17.5% solution of sodium hydroxide. Cellulose may be used in saccharification and ethanol fermentation research [18, 19].

Based on Figure 3, *Leuceana leucocephala* has higher α-cellulose content, and the highest is in its middle portion of bark (69.36%). Based on Table 2, α-cellulose content between species is highly significant (r = 68.848**) and parts also shows statistical significance (r = 4.800*). However, no statistical significance found for portions (r = 0.049ns). Table 3, Tukey's Post Hoc Test shows no significance at all between portions for α-cellulose content.

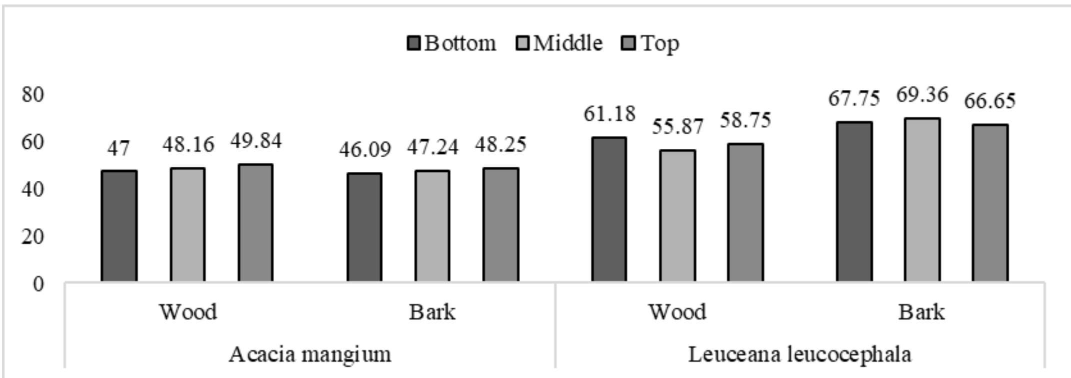

Figure 3. Comparison of α-cellulose percentage between small diameter wild *Acacia mangium* and *Leucaena leucocephala* species in portions and parts

3.4 Hemicellulose Content

Hemicellulose found in hardwood trees is predominantly xylan with some glucomannan, while in softwoods it is mainly rich in galactoglucomannan and contains only a small amount of xylan. Unlike cellulose, hemicellulose (also a polysaccharide) consists of shorter chains 500–3,000 sugar units as opposed to 7,000–15,000 glucose molecules per polymer seen in cellulose [20].

Based on Figure 4, *Acacia mangium* has higher hemicellulose content, which mostly resides in wood part. Highest is in top portion of *Acacia mangium* wood (36.14%). Based on ANOVA in Table 2, hemicellulose content between species ($r = 17.351^{**}$) and parts ($r = 160.059^{**}$) are highly significant, while between portions, there is no significance ($r = 0.855^{ns}$).

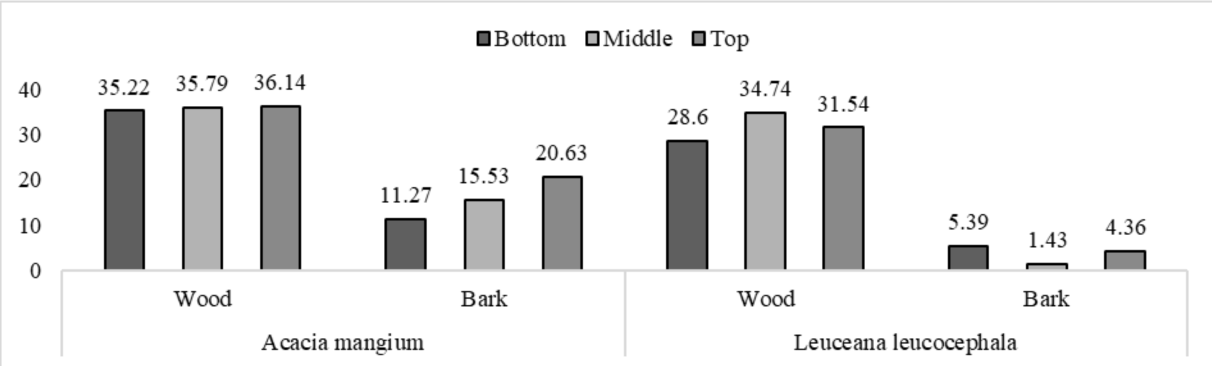

Figure 4. Comparison of hemicellulose percentage between small diameter wild *Acacia mangium* and *Leucaena leucocephala* species in portions and parts

3.5 Lignin Content

Lignins are particularly important in the formation of cell walls, especially in wood and bark, because they lend rigidity and do not rot easily. Chemically lignins are cross-linked phenol polymers and are cross-linked phenol polymers [21]. During pulping process, some of the lignin is hydrolysed by chemical materials. High lignin content also increase the beating required to pulp, produces weak fiber bonding and low paper strength [22].

Based on Figure 5, for wood part, *Acacia mangium* has lower lignin content compared to *Leuceana leucocephala*. Highest is in *Acacia mangium* bottom bark (31.18%). Based on Table 2, statistical analysis shows that lignin content is highly significant between species ($r = 25.433^{**}$). However, there is no statistical significances found for portion ($r = 1.583^{ns}$) and part ($r = 0.001^{ns}$). Panshin & de Zeeuw [23] stated that generally it has been reported that lignin content shows a general decrease from pith to bark but does not show any significant increase from bottom to top of the tree.

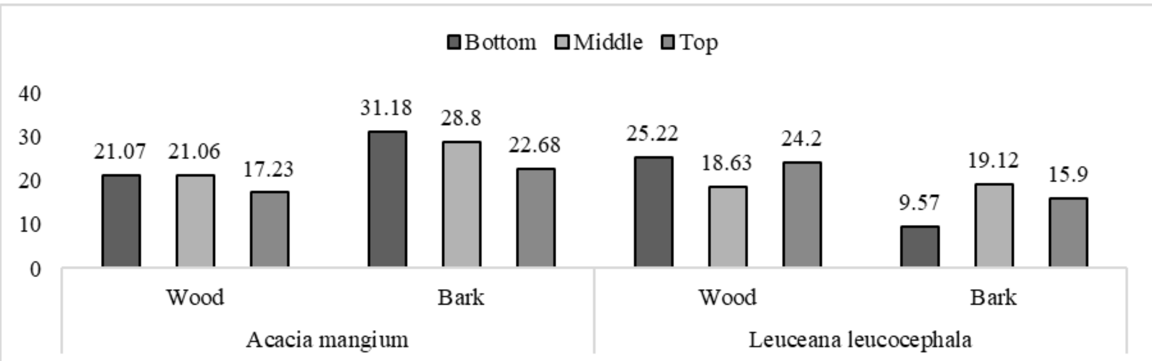

Figure 5. Comparison of lignin percentage between small diameter wild *Acacia mangium* and *Leucaena leucocephala* species in portions and parts

4. Conclusion

In this study, chemical composition of small diameter wild *Acacia mangium* and *Leucaena leucocephala* was determined and compared between species, for portions and parts. *Acacia mangium* has higher alcohol-toluene solubles and hemicellulose. Holocellulose and α-cellulose content in *Leucaena leucocephala* is higher. Lignin is higher in *Leuceana leucocephala* wood. ANOVA revealed that there is a statistically significant difference between species for all chemical compositions, and between portions, only alcohol-toluene solubles and holocellulose are significant, while for part, all chemical compositions are significant except for lignin. Tukey's Post hoc revealed that only alcohol-toluene solubles and holocellulose content are significant, which is top portion compared to bottom and middle portion. This research hopefully may give an understanding for future researchers in terms of paper and pulp industries. Last but not least, this study hopefully be able to assist in future researches.

5. Acknowledgement

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